

**Short communication**

Killer whales (*Orcinus orca* L.) and saithe (*Pollachius virens* L.) trap herring (*Clupea harengus* L.) in shallow water by taking advantage of steep bottom topography

Leif Nøttestad

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## Abstract

Whales and fish use a wide range of hunting tactics in order to catch their prey. Predator-prey interactions have been seen during the massive wintering of herring (*Clupea harengus*) in steep bottomed topography in Lofoten, northwestern Norway. We applied hydro-acoustics to document how killer whales (*Orcinus orca*) and Atlantic saithe (*Pollachius virens*) herd and trap herring in shallow waters before attacking their prey. A group of eight killer whales and a shoal consisting of hundreds of saithe concentrated their attack on the side of the herring schools that faced away from the shallow area. They thus effectively herded the herring towards the shallower water. The predators then surrounded the schools, preventing the herring from escaping to deeper, darker and safer water. Some predators attacked herring by penetrating the school, while others continued surrounding the school. These are the first, well-documented hydro-acoustic observations of this hunting tactic. Further research will reveal if this hunting tactic is common and widespread among other species of marine mammals and fish preying on fish schools in coastal waters.

Keywords: herring, killer whale, saithe, hunting tactic, bottom topography, trap.

*Leif Nøttestad: Institute of Marine Research, Division of Resource Ecology, 5817 Bergen, Norway. [Tel: + 47 55 23 68 09, fax: +47 55 23 68 30, email: leif.nottestad@imr.no].*

## Introduction

Feeding strategies in fish and marine mammals reflect their abilities to capture prey for their survival and growth (Dawkins and Krebs 1979; Pitcher and Parrish 1993; Bowen 1997; Baird 1999). There exist numerous attack strategies in the aquatic environment, and both predatory fish and marine mammals perform advanced hunting for pelagic fish (Similä and Ugarte 1993; Nøttestad 1998; Saulitis et al. 2000). Nevertheless, observing these attacks and their interactions *in situ* under natural undisturbed conditions is far from simple, due to their highly dynamic nature and short duration (Lima and Dill 1990; Nøttestad et al. 2002). It is difficult to know when, where and how these attacks and interactions may appear. With this in mind, we pre-selected specific locations with previous knowledge about frequent visually observed predator-prey interactions in Lofoten, northern Norway.

The field study aimed at documenting how Atlantic saithe (*Pollachius virens* L.) and killer whales (*Orcinus orca* L.) attack wintering herring in shallow water. The intention was to observe predators and prey simultaneously and gather quantitative and qualitative data on marine mammal-fish and fish-fish interactions.

## Materials and methods

The recorded behavioural interactions between a group of killer whales pursuing a herring school and a shoal of saithe attacking herring were made in Tysfjord and Vestfjord, 18 November 1996. The 16-m research vessel R/V “Fjordfangst” was equipped with FURUNO CH-12 multi-beam sonar (150 kHz) and a PC-based SIMRAD

EY-500 (38 kHz) connected to an echo-integrator, which quantifies swimming depth, vertical extension and biomass of a herring school. A colour-printer recorded the echosounder signals and ping-to-ping data were regularly stored on a 1.3 GB optical disk. The time and position from the navigation log and the global positioning system (GPS) were recorded on the echogram every 120 sec. Temperature and salinity were measured through the whole water column right after each behavioural event with a standard STD-sensor.

Onboard R/V "Fjordfangst" general behaviour, size and sex of the killer whale group were observed. A rough estimation of number of saithe attacking the herring school was done based on the echograms. Size composition of saithe and stomach contents was estimated based on a sub-sample (n=50) of a catch of saithe onboard a purse-seiner in the same area and at the same time as our interaction studies.

## Results

The weather conditions were good with easterly calm wind and partly cloudy, giving proper conditions for reliable hydro-acoustic (sonar and echosounder) and visual observations. The air temperature was 5°C, sea temperature between 6.7 °C at 10m depth and 8.2 °C at 50 m depth. Salinity was between 31.6 ‰ at 10 m and 32.9 ‰ at 50m depths.

During the two-week cruise, these shallow water predator-prey interactions were only taking place 18 November 1996 during daytime in Tysfjord, north-western Norway. A group of eight killer whales including one large male and two large females were

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observed to herd and attack herring into shallow water. An estimated number of 200-500 saithe, probably ranging from 3-8 kg based on catches from the commercial purse-seiner in the same area, were involved in the co-ordinated hunt for herring in shallow water. Sub-samples of the stomach content from the caught saithe revealed that 85% of the saithe had very recently been eating adult herring, confirming that predator-prey interactions between saithe and herring were taking place in the area.

The estimated biomass of the herring school being attacked by killer whales was 17 tons, with an average density of 3.5 individuals per  $m^3$  (Figure 1). The herring school had an average swimming depth of 32 m before the attack, and 18 m after being herded to shallow water. Total vertical extension of the school was about 25 m. Bottom depth rose from 49 m up to 26 m within a distance of about 60 m, giving a  $38^\circ$  elevation of the slope. It took about four minutes to herd the herring from deep to shallow water. The killer whales only concentrated their attack on the side of the herring schools that faced away from the shallow area as seen in Figure 1. After herding the herring to shallow water, the killer whales surrounded the school and attacked the herring by tail-slaps and penetration of the school as observed from the surface-area.

The estimated biomass of the herring school being attacked by the saithe was 14 tons, with an average density of 4.2 individuals per  $m^3$  (Figure 2). The herring school had an average swimming depth of 36 m before the attack and 14 m after being herded to shallow water. Total vertical extension of the school was about 28 m. Bottom depth rose from 61 m up to 37 m within a distance of about 70 m, giving a  $34^\circ$  elevation of the slope. It took about six minutes to herd the herring from deep to shallow water. The saithe mainly concentrated their attack on the side of the herring schools that faced away

from the shallow area when herding the herring. However, when the saithe attacked the herring they spread out and surrounded the school at the top of the underwater “hill” as seen in Figure 2.

## Discussion

Whales and fish use a wide range of fascinating hunting tactics in order to catch their prey. This is the first study acoustically documenting how both killer whales and saithe take advantage of the steep bottom topography in Lofoten, in order to effectively herd and trap herring schools in shallow waters. Hunting is easier for visual and acoustic predators in shallow water, due to improved light conditions for visual hunting (pursue and catch) (Nøttestad 1998), reduced vertical escape possibilities for herring (Axelsen et al. 2001) and lower ambient water pressure beneficial for the killer whales during tail-slapping aimed to kill and stun herring swimming nearby (Similä and Ugarte 1993; Nøttestad and Similä 2001).

This study demonstrates that both killer whales and saithe apply similar hunting strategy for schooling herring. Although the number of predators involved in the attack is different between the whales (8) and the predatory fish (100s), both predator species coordinate their attack and take advantage of the steep bottom slopes to herd herring in shallow water masses. Both killer whales and saithe concentrate their herding of herring from only those sides of the school turning away from the slope, forcing herring to swim up the steep slope, where they are more vulnerable to predation. The predators then surrounded the schools, preventing herring from escaping to deeper, darker and safer water. Further research will reveal if this hunting tactic is common and widespread

among other species of marine mammals and fish preying on pelagic fish schools in coastal waters with similar bottom topography.

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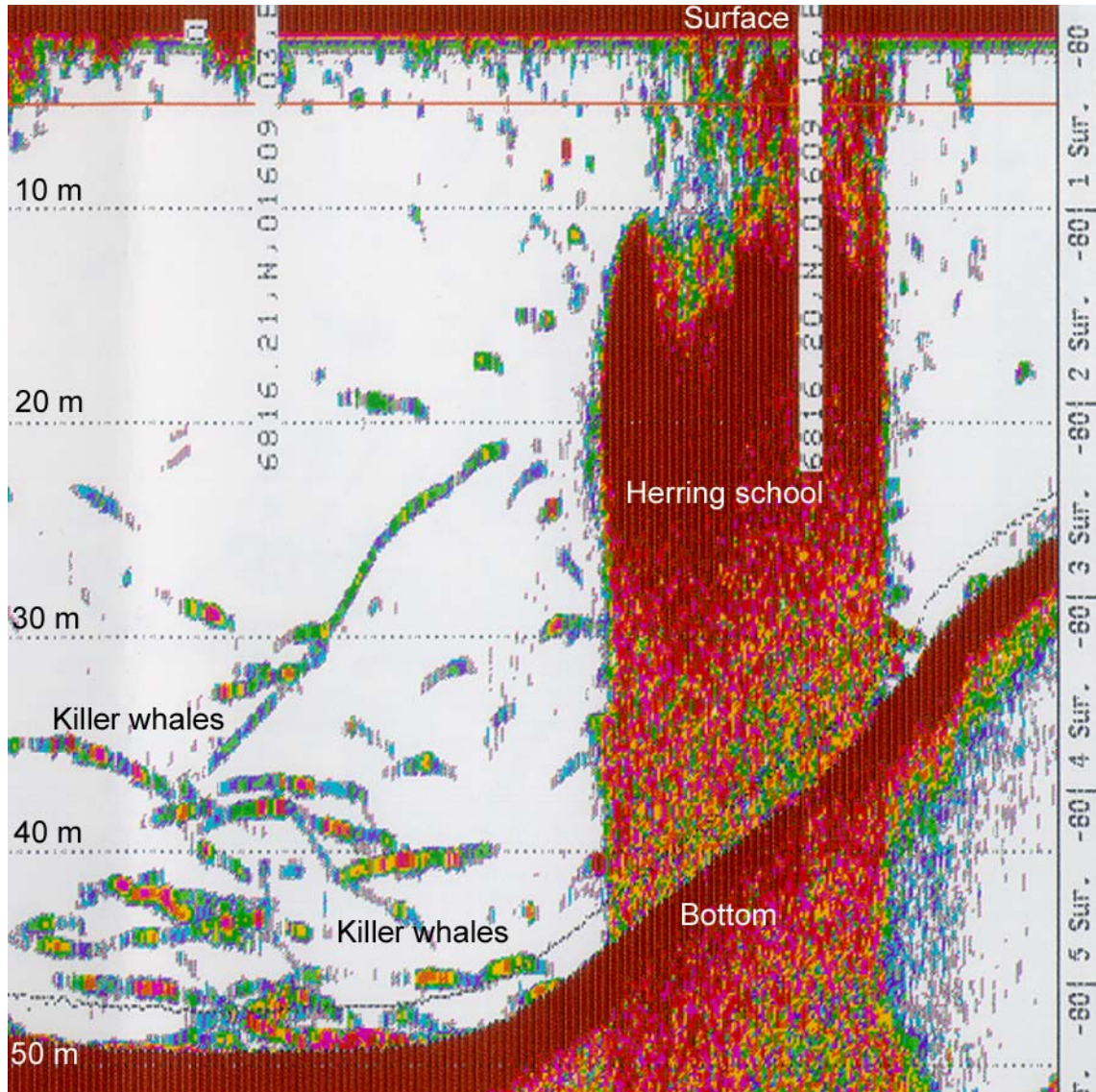
## Figure legends

### Figure 1.

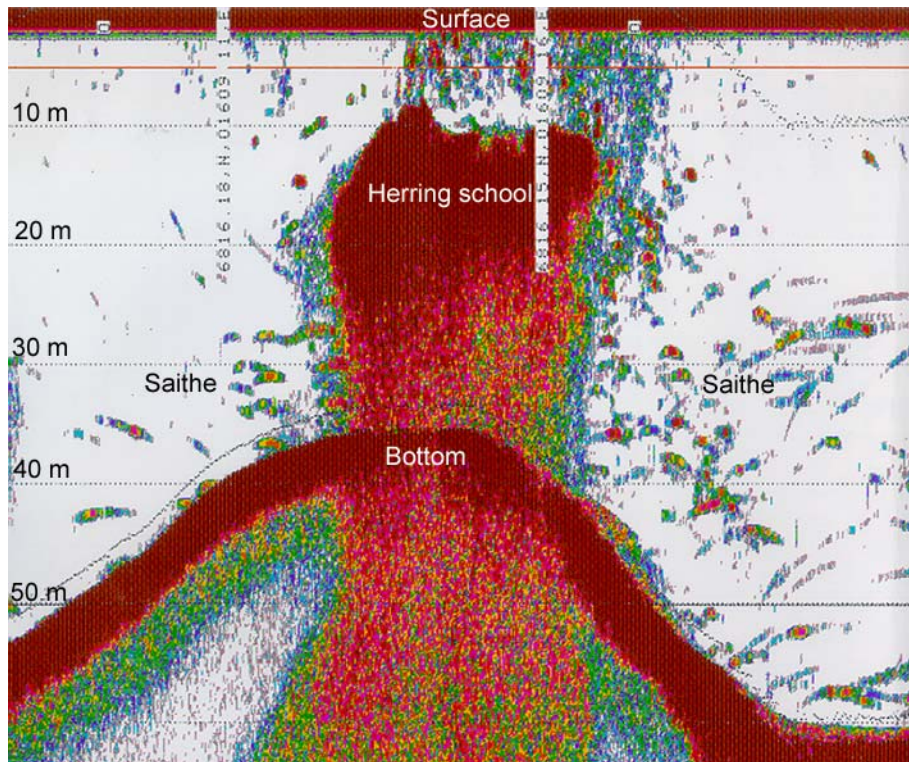
A total number of eight killer whales herding a very dense school of wintering herring from approximately 50 m depth up towards shallow water (<25 m) taking advantage of the steep bottom topography. The echogram illustrates the first herding stage of the hunting tactic.

### Figure 2.

A shoal of large saithe surrounding and attacking a small and very dense school of herring at the most shallow bottom depth at 37 m. Bottom depth rapidly increases on all sides of the trapped herring and saithe could prevent herring from diving to deeper water by surrounding the herring as seen on the echogram. The echogram illustrates the second attack stage of the hunting tactic.



*Figure 1*



*Figure 2*